

"E"

S.S. "Nausicaa"

Further remarks upon the corrosion of the shell plating of this vessel.

With reference to the note from the Director of the Ecole Centrale des Arts et Manufactures to M. Andrade the managing Director of the Company owning this vessel, commenting upon the remarks which I submitted on the 31st July last I beg to offer the following observations.

The specimens of steel which were submitted to the Director of the Ecole were cut from two of the most corroded plates in the vessel. Two were taken from a badly corroded part of plate E.9, Four were taken from corroded parts of plate E.8 and two were taken from intact parts of the two plates E.8 and E.9 respectively.

The chemical analysis A was made from the corroded sample taken from plate E.9. Analyses C & D were made from the corroded samples taken from plate E.8 and Analysis B was made from a mixture of metal taken from the uncorroded parts of both plates.

As the results of all four analyses are practically identical it follows that the composition of both plates was substantially the same and that there was no difference observable between the compositions of the

corroded and uncorroded parts of these two plates. Further, the analyses show that the impurities in the steel were less than are usually found in ordinary structural mild steel. For example the average of the figures given for phosphorous is 0.0265 per cent, whereas 0.05 per cent would not lead to rejection in most cases where chemical analysis is specified. In the case of Sulphur the results given are remarkably low, much lower than would be expected from the remarks in the Report from the Ecole concerning the presence of sulphides.

It is stated in the first report that the carbon content of the steel was estimated from the photographs & that the tests for the presence of oxides were also made by microscope. I am not conversant with the method for this latter determination, which is the result of comparatively recent research. I would observe however that one would not expect to find an undue amount of iron oxide in steel containing so much as 0.2 per cent of carbon, as it is only in low carbon steels that troubles from oxide are occasionally met with.

In my previous remarks it was mentioned that when dealing with microphotographs it must be remembered that the magnification is great and that the large impurity mentioned in the

report is really so small as to be invisible without microscopic aid. These remarks have been adversely criticised and the statement made that a micrographic enlargement of 200 diameters does not merit the qualification of "considerable". This magnification (200) is a very usual one for purposes of research, but it must be remembered when using it that the area actually seen in the microscopic field is really only $\frac{1}{40,000}$ of the apparent size, so that what appears to be a serious defect may in reality be negligible.

As a particular example one apparently large slag inclusion is seen in fig 8, which has this magnification, but the whole field of view has a real diameter of only 0.4 mm , which is one half of the diameter of an ordinary domestic pin. This same slag inclusion is shown at a magnification of 500 diameters in figure 9 and there stretches nearly across the field, but this field of view is only one-fifth of the diameter of the pin, and the apparent area of the inclusion is 250,000 times the real area. The length of this inclusion is 0.136 mm (about $\frac{1}{200}$ of an inch).

In N°2 photograph, the report refers to "in particular a large impurity right in the middle of the photograph". The length of this is really 0.12 mm which is less than $\frac{1}{200}$ of an inch, and its greatest breadth

is about $\frac{1}{1000}$ of an inch. These figures in my opinion fully justify the use of the word "considerable."

As stated in the remarks made on 31st July last there is always some segregation near the top of every ingot which is rolled into plates. In this portion there will always be found more than the average of the impurities of the steel, but so long as this portion is mechanically sound it is not discarded. When the ingot is rolled into a plate this part becomes the centre of the thickness at about the centre of the width near one end of the plate. A specimen cut from this part when examined microscopically always presents some of the peculiarities mentioned in the report from the Ecole. The outer portions will be normal in structure whilst the centre portions will contain some minute slag inclusions.

Whilst dealing with this segregated portion of the plate it should be observed that Lloyd's Rules prescribe that tests of plates are to be taken both lengthways and crossways of the plate. A crossway test from this end of the plate is taken from the very worst part of the plate if its quality is judged from its chemical composition, the part being immediately adjoining the discarded portion. This does not justify the Director's conclusion

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N^o 3, viz that Lloyd's tests are insufficient.

As regards figure 3, which shews sulphur markings upon 4 specimens, it must not be thought that these markings necessarily indicate that the steel is of bad quality. Sulphur exists in all structural steel, and very slight amounts of this element produce dark markings on silver bromide paper. The analyses made shew that the sulphur in this case is exceptionally low even although the photographs shew that the samples analysed were taken from the most segregated part of the plate. A percentage of 0.05% ^{of sulphur} is always considered to be unobjectionable in structural steel and with such an amount of sulphur the Baumann print would be much more strongly marked.

The photographs in both figures 3 and 11, which in each case are actual size, shew that the impurities they indicate, viz sulphur and iron oxide, are concentrated near the centre of the thickness and are practically absent from the portions near the surface of the plate, which are the portions which have suffered from corrosion. This is especially noticeable in specimen 7 which shews the depression of an actual zone of corrosion. In figure 11 this part is the most free from markings.

The real object of the enquiry is to ascertain the cause of the corrosion. It is necessary to consider the actual facts which

are recorded in the Reports of Survey. The following are taken from the Reports.

The most serious of the corrosions of plates are confined to the strakes E. & F. It is mentioned that a number of rivet points in the corroded plates and also throughout the bottom are more or less corroded. In this vessel the rivets are of iron.

There are two kinds of corrosion recorded as affecting the plates, the defects being variously described as "corrosion" "patches of light corrosion" "patches of corrosion" "corrosion general".

Corrosion is also described as "pitting" and "grooving". As regards the latter there are mention of a bad place 4 inches long $\frac{1}{8}$ inch deep. Another is mentioned as 4 inches long $\frac{3}{8}$ inches broad $\frac{1}{8}$ inch deep. There is mention of grooving in middle of plate for a length of 3 feet, Horizontal grooving about 7 feet long. Two vertical grooves about 14 inches long. Corrosion and grooving in 3 places in plate E. 8. S.

3 bad vertical grooves in plate E. 6. It is further stated that some of the grooves are as if pieces of half round iron about 14 inches long $\frac{3}{8}$ inches broad and $\frac{1}{8}$ inch deep had fallen out of the plating.

These defects are all such as may be expected if the paint of the vessel had been damaged. The rivet points always protrude somewhat above the plate surfaces and are therefore most susceptible to having the paint

rubbed off. The patches of corrosion are what would be expected if the paint is rubbed off in patches. The grooves are most probably the result of the paint being removed by local scratching. It will be noticed that where the directions of the grooves are mentioned they are recorded as being either horizontal or vertical. The long ones are always horizontal. These would be the result of scratching in the direction of the vessel's length, whilst vertical scratches would be caused by the vessel rising or falling with the tide when moored alongside a wharf.

All steel will corrode if exposed to water or weather if the surface is not protected by paint, and it is usually found that where protective coatings are removed locally leaving large portions effectively covered the corrosive action on the exposed parts becomes intensified forming "pitting" + "grooving" where the exposed portions are small, and "corroded patches" where they are larger.

That the chemical composition of the steel is not at fault is shown by the iron rivets being attacked, by the fact that there is no difference in the chemical composition of the plates where they are unattached and where the corrosion has been most intense, and by the position of most of the defects being on the strakes most likely to be affected by outside influences.

J. J. Mutton
13 November 1923.